AUTONOMOUS OPERATIONS OF NASDA SPACE NETWORK EXPERIMENT SYSTEM

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ABSTRACT

The DRTS Space Network Control System (SNC) provides the autonomous operation capability to the overall DRTS Space Network experiment ground system (DRTS SN) for experiment operation via DRTS that is a data relay test satellite launched in the Summer 2002. This paper summarizes the autonomous control of DRTS SN and inter-orbit communication experiment between DRTS and ADEOS-II in February 2003.

1. INTRODUCTION

The Data Relay Test Satellite (DRTS) was developed as the NASDA's inter-orbit communication experiment satellite, and the DRTS Space Network experiment ground system was developed as the ground station for the inter-orbit communication experiment. The DRTS SN consists of 1 data relay satellite (DRTS), 2 Feeder link stations (Primary Ground Terminal and Hatoyama Ground Terminal), 1 DRTS System calibration Station (DSS), and 2 Ka-band ranging station for DRTS. All these are remotely monitored and controlled by ground software system in Tsukuba Inter-orbit Communication Station (TICS). The ground software system consists of the DRTS SN Control system (SNC), SN Planning system (SNP), and SN Analysis system (SNA).

The DRTS SN also has capabilities of remote monitor and control of NASDA base-band processing equipments in ESA Redu station realizing autonomous inter-orbit experiment operation with ESA ARTEMIS.

Figure 1 shows overall configuration of the system.

The integration test and verification to the functional autonomous operations capability of the DRTS SN had completed in 2001. The DRTS was launched in September 2002, and confirmed the own onboard function and characteristic in the initial checkout phase.

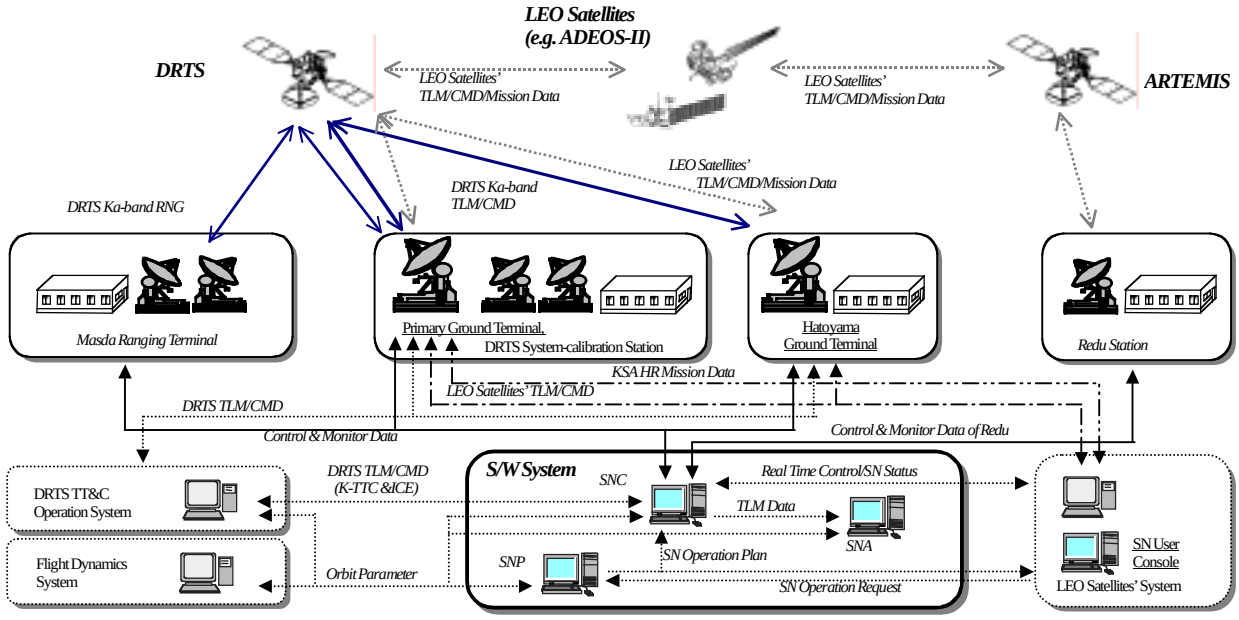


Figure 1. DRTS SN System Configuration

2. AUTONOMOUS OPERATION SYSTEM

Autonomous operation of the DRTS SN is realized the DRTS Space Network Control System (SNC) and the DRTS Space Network Planning system (SNP) in its own software. Therefore, it specify concerning the DRTS SNC and the DRTS SNP.

DRTS Space Network Control System (SNC)

The DRTS SNC is a core software system of the DRTS SN, which controls and monitors the DRTS and all ground station.

The DRTS SNC consists of the following 5 units:

- DRTS System Control Unit
- DRTS Mission control unit
- Station Control Unit
- ARTEMIS System Control Unit
- Common Information Management Unit

The DRTS System Control Unit, the DRTS Mission control unit and the Station Control Unit are mainly used for real-time operation of the inter-orbit communication experiment between DRTS and LEO satellites.

The DRTS System Control Unit is core unit in the SNC, which is in charge of monitoring and control of the Ka-band TT&C Operation for DRTS TT&C and the SN Experimental Operation including the establishment of inter-obit communication link between DRTS and LEO satellites. This unit autonomously controls its subordinate the DRTS Mission Control Unit and the Station Control Unit in accordance with the DRTS SNP generated plans.

The Mission Control unit monitoring the DRTS Inter-orbit Communication Equipment (ICE) telemetry and generate pre-planned command sequences based on the directions from the DRTS System Control unit.

The Station Control unit is located between DRTS System Control Unit and Station Control and Monitoring Equipment (CME) in each station. Based on the operational directions from DRTS System Control Unit, this controls each station-equipment via CME in each station.

DRTS Space Network Planning System (SNP)

Coordinating operation requests from LEO satellite's planning system, the DRTS SNP automatically generates DRTS Ka-band TTC operation schedule and SN experiment operation schedule considering the visibility information, the priority rule, and the restrictions of data relay satellite and ground systems. After the assigned LEO satellite operation requests, this generated schedule is distributed to related system (e.g. the Earth Observation Center, Gateway System of the Tracking and Control system.) including the DRTS SNC automatically.

Automatic Experiment Based on Schedules

The operation schedule is submitted from the DRTS SNP to the DRTS SNC once per day automatically. The DRTS SNC proceeds and expands its operation plan as shown in Figure 2. The DRTS SNC starts preparing for events 60 minutes before the start time of real operations. The DRTS SNC refers to SN Operation Plan Table every seconds checking the scheduled start time of events.

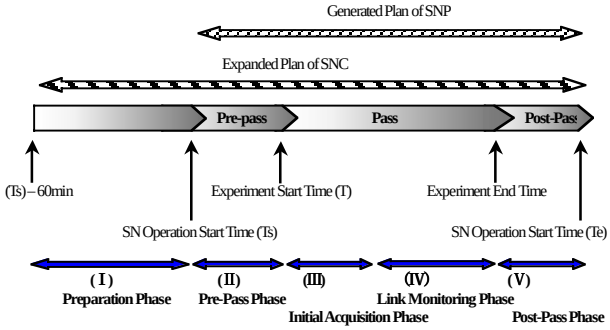


Figure 2. Outline of the SN Experimental Operation Flow

"Pre-pass", "Post-pass" and "Initial Acquisition" in Figure 2 is defined as individual work items. They are executed one by one based on the directions of the Operation Scheduler in the DRTS SNC. Detailed operation in each work item shows as follows.

(I) Preparation Phase
- Start to prepare the station equipment for operational use
- Acquire the Acquisition and Tracking Aid information for Doppler Compensation.

(II) Pre-Pass Phase
- DRTS onboard equipment set up and IOL antenna pointing
- Start to transmission Ka-Forward Beacon toward LEO satellite in the case of KSA operation request included in the plan.
- Feeder-link station equipment set up after the readiness check
- Ranging calibration
- Connect the data and operation line with LEO satellite TT&C operation console.

(III) Initial Acquisition Phase
- Establish SSA inter-orbit communication link include DRTS and ground station.
- Establish KSA inter-orbit communication link include DRTS and ground station.

(IV) Link Monitoring Phase
- Watching for the inter-orbit communication link, DRTS

ICE equipment status, and ground station equipment status.

- Start the Range and Range Rate measurement
- Change the parameter of DRTS and ground station if necessary (e.g. from SSA only to S+K simultaneously).

(V) Post-Pass Phase

- Terminate the RF signal transmission from each satellite.

3. INTER-ORBIT COMMUNICATION EXPERIMENT BETWEEN DRTS AND ADEOS-II

Demonstration and Verification Schedule

Figure 3 shows the schedule of verification schedule from the DRTS initial checkout phase to the DRTS/ADEOS-II test experiment phase.

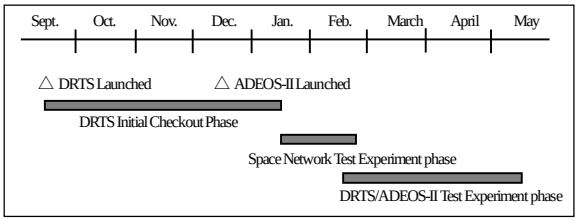


Figure 3. Schedule

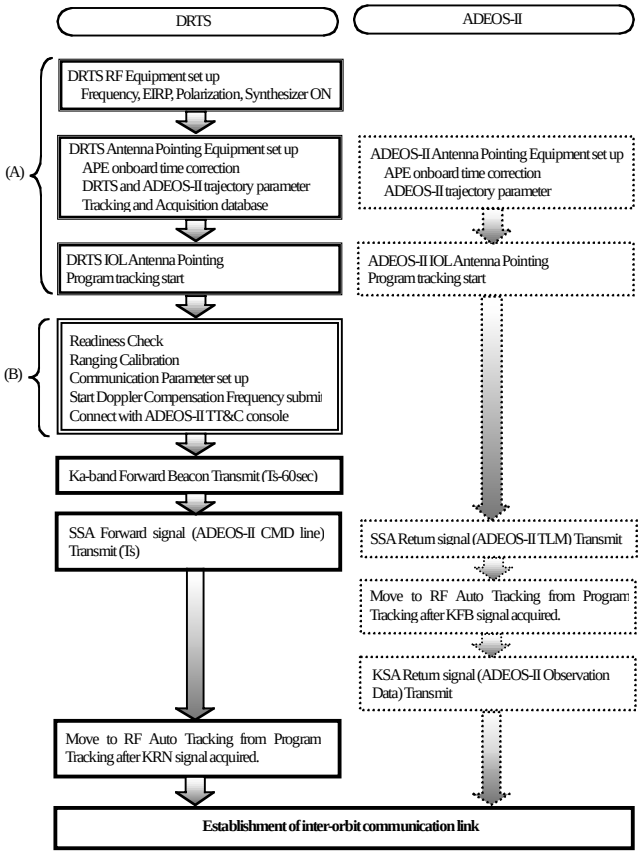
Demonstration of Autonomous Operation using DSS

Throughout the DRTS initial checkout phase and Space Network test experiment phase, the DRTS SN demonstrated its autonomous capability including various hardware and software timing adjustments with the DRTS System calibration Station (DSS). The DSS is able to simulate the function of LEO satellites.

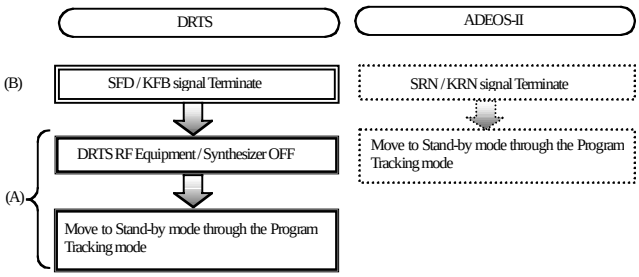
This demonstration was started from the ground to space link establishment to the DRTS onboard equipment control from the ground toward the DRTS/ADEOS-II inter-orbit communication. During the first phase of the demonstration, conventional TT&C operation console was used for the automated process and procedure verification. Before the inter-orbit communication operation with ADEOS-II, the DRTS SN was transferred the TT&C authority from the conventional TT&C system. Moreover, in this Space Network test experiment phase, this demonstration performed for team training.

Demonstration of Autonomous Operation with ADEOS-II

After the above demonstration, the DRTS SN demonstrated to establish inter-orbit communication link between DRTS and ADEOS-II from February 2003. Figure 4 shows as flown inter-orbit communication operation flow. The left side sequence is for the DRTS SN, and the right side is for the ADEOS-II. Although the ADEOS-II is controlled by up-lording Stored-Command, the DRTS and all station equipments ware controlled by the DRTS SNC at the real time.



i). Pre-Pass and Initial Acquisition Phase



ii). Post-Pass Phase

Figure 4. As flown Inter-Orbit Communication Operation

In this demonstration phase, the DRTS SN verified its autonomous operation capability for the establishment of inter-orbit communication link using the ADEOS-II on orbit, including the hardware and software timing adjustments concerning the each satellite corresponding.

Moreover, the DRTS SN demonstrated the simultaneous operation, DRTS onboard equipment control ((A) in Fig. 4),

and station equipment control ((B) in Fig.4). For instance, the Interface Control Document (ICD) is defined that Ka-band Forward Beacon (KFB) signal should be started to transmit 1 min before SN experiment start time ((T) in Fig. 2), therefore the DRTS SN transmit KFB signal without other equipment's control completed. The DRTS System Control unit is observing and gathering the set up progress from DRTS Mission Control unit and Station Control unit for KFB equipment, and both unit set up is completed, the DRTS System Control unit direct the Station Control unit to start KFB transmission. The series of these processes for KFB transmission, it is not necessary that SN operator intervene.

Concerning the simultaneous operation, it is possible to be the Network operator concurrently DRTS satellite's operator. Also, during the first phase of this demonstration, these operations conducted sequentially, therefore it takes over 20 min to perform pre-pass operation completed. In short a word, "Pre-Pass" and/or "Post-Pass" operation time became shorten. The time reduction due to the simultaneous operation will be effective the multi LEO satellites operation support in future.

COST REDUCTION APPROACH

Basically autonomous operation capability of the DRTS SN had completed the verification. Throughout this demonstration, the DRTS SN has built up the autonomous operation, and SN operation personnel are less than less.

Moreover, most important characteristic in this system, which is compared with conventional Tracking and Control system of NASDA, is unified Network operation and Satellite operation except for House Keeping operation. (The DRTS SN has authority to control DRTS Mission equipment only.) The results of the unity the Network and Satellite operation, the operation personnel ware rationally, however if the DRTS SN have authority the control of DRTS House Keeping operation, the operation cost will be reduced more.

LESSONS LEARNED, FUTURE WORKS

- The SNC is required to improve efficient resource assignment maximizing experiment opportunity.
- The SNP is required to adjust SN operation constraints to enable efficient and flexible operation.
- To demonstrate and improve the autonomous operation throughout the future LEO satellite, for example ALOS, JEM.